Forest Health Protection
Pacific Southwest Region

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To: District Ranger, Yuba River Ranger District, Tahoe National Forest

Subject: Evaluation of Stand Conditions in the Canyon Forest Health Project (FHP Report NE07-07)

At the request of Terri Walsh, Silviculturist, Yuba River Ranger District, Tahoe National Forest, I conducted a field evaluation of proposed treatment units within the Canyon Forest Health Project. The objective of the visit was to identify any insect and disease issues, evaluate stand conditions, discuss treatment options including the use of Forest Health Protection funding for stand level treatments under the Western Bark Beetle Program. Recommendations provided in this report will assist with the development of silvicultural prescriptions and other management options for these stands. Terri Walsh, Janet Cowell and DeeDee Cherry accompanied me in the field.

Background

The Canyon project area is located about 12 miles NE of Camptonville, CA between Deadwood Peak and Eureka Diggings at elevations ranging between 4500 and 6500 feet (centered in the middle of townships T21N, R9E: T21N, R10E; T20N, R9E; and T20N, R10E). Annual precipitation is approximately 70 - 80" inches. This area is primarily Sierra mixed conifer with ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), white fir (*Abies concolor*), red fir (*Abies magnifica*), sugar pine (*Pinus lambertiana*), incense cedar (*Libocedrus decurrens*), Douglas-fir (*Pseudotsuga menziesii*) and black oak (*Quercus kellogii*). The objectives for this approximately 2000 acre project area are to thin trees to reduce stand density, increase structural and spatial diversity, enhance black oak, release large diameter conifers and reduce fuels. Fuel reductions will be further achieved through mastication and/or prescribed fire. Past management activities include some precommercial thinning, selective harvesting of large diameter trees and

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prescribed burning. Most of this project area was heavily utilized for placer and quartz mining during the gold rush era which caused severe ground disturbance in some locations.

Observations

Note: Due to the large size of the project area, all observations of stand conditions and associated insect and disease activity were made from main roads. Most project units were not inspected and significant insect and disease issues may exist that were not captured during this brief evaluation.

Ponderosa and Jeffrey pine near Deadwood Mountain are heavily infected with western dwarf mistletoe (*Arceuthobium campylopodum*). All tree species growing in this harsh area are exhibiting poor crown vigor and slow growth.

White pine blister rust (*Cronartium ribicola*) was observed in a few sugar pine mainly causing branch dieback in larger trees and top kill in smaller trees. Mountain pine beetle (*Dendroctonus ponderosae*) has attacked and killed a few of these infected trees over the last couple of years.

Fir engraver beetles (*Scolytus ventralis*), roundheaded fir borers (*Tetropium abietis*) and flatheaded fir borers (*Melanophila drummondi*) are likely present in many of the dying white and red fir that were previously injured by prescribed fire (Figure 1). These trees received high levels of cambium injury to their lower boles as indicated by sloughing bark and decayed patches of exposed sapwood. In addition, many of the currently green crowned fire-injured true fir have many of these same types of injuries. Significant bole injury was also observed on black oak.

Figure 1. Dead and dying fire-injured white fir trees in 10+ year old prescribed burn area.

Scattered individual white fir throughout the project area, and not associated with prescribed fire, have been attacked and killed by fir engraver beetles over the last couple of years.

Annosus root disease (*Heterobasidion annosum*), although not directly observed, is likely present within many of the stands and negatively affecting the health and vigor of true fir.

Discussion and Recommendations

Very little tree mortality directly attributable to insects and/or pathogens was observed within the project area. This condition is typical for this forest type on the west side of the Sierra Nevada range due to the very high annual precipitation and high site quality. However, most stands are currently overstocked, ranging between approximately 400 and 550 on the stand density index (SDI); the maximum SDI for mixed conifer in this area is approximately 600. This puts most of these stands in a relative density range of 66 – 92 percent. This is well above the regional forester's recommendation for density management that suggests SDI levels be maintained

below 60% of maximum SDI. This high stand density also puts these stands at risk for elevated levels of bark beetle caused mortality during any extended period of below normal precipitation.

This area has become very dense with white fir through past management activities and with the exclusion of fire over the past 100+ years. With such a high percentage of white fir in the area, shade intolerant species such as ponderosa pine and black oak, as well as many shrub species, tend to decline due to competition for sunlight, water and nutrients. Higher percentages of white fir in mixed conifer stands can also increase susceptibility to defoliation events caused by the Douglas-fir tussock moth (DFTM) (O*rgyia pseudotsugata*). In California, white fir is the preferred host species for the DFTM and outbreaks have tended to occur on ridge tops, upper slopes and generally poorer sites with high percentages of white fir. Past outbreaks where heavy defoliation has occurred resulted in approximately 20 - 25 % morality with lower levels of top kill. Management practices that increase stand vigor, increase species diversity and promote even aged stand characteristics for the white fir component will increase resistance to DFTM.

The proposed thinning treatments should reduce the density in most stands to a level that reduces the risk of bark beetle caused mortality. In most cases, thinning to a stand density that is 80% or less of "normal" for the site would effectively reduce tree competition for limited water and nutrients and reduce the susceptibility to future bark beetle related mortality. Thinning treatments should also be consistent with recent direction from the Regional Forester that suggests designing thinnings to "ensure that density does not exceed an upper limit (for example: 90% of normal basal area, or 60% of maximum stand density index)" and to "design thinnings to ensure that this level will not be reached again for at least 20 years after thinning." (Regional Forester letter, "Conifer Forest Density Management for Multiple Objectives", July 14, 2004). However, some areas within the Canyon project will require the maintenance of high canopy closure levels for wildlife, resulting in higher stand densities than the recommended upper limit. If canopy cover requirements do not allow for a reduction in stand density that increases the health and vigor of residual trees, the risk for bark beetle caused mortality will remain, especially during prolonged periods of drought. Failure to reduce the risk of bark beetle caused mortality could result in significant mortality and reduce the habitat suitability for some wildlife species.

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pines and black oaks, should benefit by having the stocking around them reduced to lower levels. Areas of pure or nearly pure ponderosa pine would also benefit from lower stocking levels as well as an increase in species diversity. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as fork-topped trees or larger ponderosa pines that have dwarf mistletoe brooms. When implementing thinning projects, retaining more drought tolerant species such as ponderosa pine, sugar pine and incense cedar over white fir will increase species diversity and make the stand more resilient to disturbance agents such as insects, disease, and fire. In addition, when selecting trees for removal, preference should be given to trees heavily infected with dwarf mistletoe, root disease and trees infested with bark beetles. Small group selections should be utilized to remove root disease pockets and clumps of trees with heavy dwarf mistletoe infections. For all thinning operations, it is recommended that a registered borate compound be applied to all freshly cut conifer stumps >14" dbh in order to reduce the chance of new infection centers being created through harvest activity. However, the treatment of white fir stumps may not be necessary if stands already have a high level of infection.

Sugar pine should be retained as much as possible during any thinning operation in order to preserve genetic diversity, especially white pine blister rust (*Cronartium ribicola*) resistant individuals. White pine blister rust, a non-native pathogen, has continued to weaken and kill this species over most of its range since its introduction into the Pacific Northwest in 1910. Identification and protection of local rust resistant trees for seed collection, if not already occurring, will aid in the future planting of rust resistant seedlings. Planting selected openings created through thinning operations with rust resistant stock would help insure this species persists in the area.

The use of prescribed fire as a primary fuels treatment or as a follow up treatment to stand thinning may result in unacceptable levels of tree mortality depending on management objectives. This mortality most often occurs as a direct result of cambium or crown injuries incurred by individual trees during the fire and not from a subsequent build up and spread of bark beetles within the burned stand. Typically, trees such as black oaks are extremely susceptible to cambium injury due to their thin bark and may be completely girdled by fire. Mature ponderosa, Jeffrey and sugar pines are also especially susceptible to mortality during prescribed burns because of the deep duff and litter that accumulates at their base. These duff mounds typically burn at a slow rate, while maintaining lethal temperatures, causing severe cambium injury. If the retention of individual high value black oak and large diameter pine is desired, such as for wildlife habitat, the District should consider raking the duff away from the bases of these trees before burning.

White fir and red fir occurring in nearly pure stands tend to have very high levels of course woody debris on the forest floor as a result of downed logs from self thinning, the continual shedding of branches and the remaining stems from old stands of brush that have been overtopped and killed by dense fir canopies. These types of stands produce tremendous amounts of heat on the ground surface and often cause severe injuries to the boles and crowns of standing trees. If high post-burn mortality levels in true fir stands, resulting in openings and possibly additional heavy fuel loading, is not an acceptable condition than fuel treatments such as hand or tractor piling should be considered prior to or in place of prescribed fire.

Potential for FHP Funding

Forest Health Protection may be able to assist with funding, including NEPA, for thinning and removing green material from overstocked areas and treating fuels within the Canyon Forest Health Project. Thinning projects in this area would meet the minimum requirements for western bark beetle funding and are supported by this evaluation. If you are interested in this competitive funding please contact me for assistance in developing and submitting a proposal.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431.

/s/ Danny Cluck

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Insect and Disease Information

Mountain pine beetle

The mountain pine beetle, *Dendroctonus ponderosae*, attacks ponderosa, lodgepole, sugar and western white pines larger than about 8 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

Evidence of Attack

The first sign of beetle-caused mortality is generally discolored foliage. The mountain pine beetle begins attacking most pine species on the lower 15 feet of the bole. Examination of infested trees usually reveals the presence of pitch tubes. Pitch tubes on successfully infested trees are pink to dark red masses of resin mixed with boring dust. Creamy, white pitch tubes indicate that the tree was able to "pitch out" the beetle and the attack was not successful. In addition to pitch tubes, successfully infested trees have dry boring dust in the bark crevices and around the base of the tree. Attacking beetles carry the spores of blue-staining fungi which develop and spread throughout the sapwood interrupting the flow of water to the crown. The fungi also reduces the flow of pitch in the tree, thus aiding the beetles in overcoming the tree. The combined action of both beetles and fungi causes the needles to discolor and the tree to die.

Life Stages and Development

The beetle develops through four stages: egg, larva, pupa and adult. The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is typical, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine. Females making their first attacks release aggregating pheromones that attract males and other females until a mass attack overcomes the tree. The adults bore long, vertical, egg galleries and lay eggs in niches along the sides of the gallery. The larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.

Conditions Affecting Outbreaks

The food supply regulates populations of the beetle. In lodgepole pine, it appears that the beetles select larger trees with thick phloem, however the relationship between beetle populations and phloem thickness in other hosts has not been established. A copious pitch flow from the pines can prevent successful attack. The number of beetles, the characteristics of the tree, and the weather affect the tree's ability to produce enough resin to resist attack. Other factors affecting the abundance of the mountain pine beetle include nematodes, woodpeckers, and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases and pine mortality increases.

Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood and the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year; however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Annosus Root Disease

Heterobasidion annosum is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Annosus root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion annosum in western North America consists of two intersterility groups, or biological species, the 'S' group and the 'P' group. These two biological species of *H. annosum* have major differences in host specificity. All isolates of *H. annosum* from naturally infected ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita have, to date, been of the 'P' group. Isolates from true fir and giant sequoia have been of the "S" group. This host specificity is not apparent in isolates from stumps; with the 'S' group being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causes the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.